

## SOLAR OBSERVATIONS

[Meteorological Research Division, EDGAR W. WOOLARD in charge]

## SOLAR RADIATION OBSERVATIONS, APRIL 1938

By CHARLES M. LENNAHAN

Measurements of solar radiant energy received at the surface of the earth are made at eight stations maintained by the Weather Bureau, and at nine cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at three Weather Bureau stations (Washington, D. C., Madison, Wis., Lincoln, Nebr.) and at the Blue Hill Observatory of Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau stations at Washington and Madison.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data obtained up to the end of 1936, will be found in the MONTHLY WEATHER REVIEW, December 1937, pp. 415 to 441; further descriptions of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parenthesis). At Madison and Lincoln the observations are made with the Marvin pyrheliometer; at Washington and Blue Hill they are obtained with a recording thermopile, checked by observations with a Marvin pyrheliometer at Washington and with a Smithsonian silver disk pyrheliometer at Blue Hill. The table also gives vapor pressures at 8 a. m. (75th meridian time) and at noon (local mean solar time).

During May 1938 direct solar radiation intensities averaged about normal at Washington, D. C., and above normal at Madison, Lincoln, and Blue Hill. The radiation received at Lincoln on the 14th and 27th was greatly depleted due to dust in the air; and also on the 28th because of smoke.

Table 2 contains the average amounts of radiation received daily on a horizontal surface from both sun and sky during each week, their departures from normal and the accumulated departures since the beginning of the year. The values at most of the stations are obtained from the records of the Eppley pyrheliometer recording on either a microammeter or a potentiometer.

Chicago, New York, Fairbanks, New Orleans, San Juan, and Friday Harbor received an excess of total solar and sky radiation during May 1938. Ten of the other stations for which normals exist received a deficiency of radiation during the month.

Polarization measurements were made on 7 days at Madison giving a mean value of 51.4 percent and a maximum of 53.5 percent on the 10th; both of these values are below the corresponding normals for the month.

TABLE 1.—Solar radiation intensities during May 1938

[Gram-calories per minute per square centimeter of normal surface]

## WASHINGTON, D. C.

Date	Sun's zenith distance										Noon	
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°		
	75th mer. time	Air mass										Local mean solar time
		A. M.					P. M.					
		e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0		
May 2.....	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.	
May 3.....	6.76	-----	-----	-----	1.17	1.18	-----	-----	-----	-----	5.79	
May 5.....	8.48	-----	-----	-----	-----	1.32	-----	-----	-----	-----	7.57	
May 6.....	11.81	-----	-----	-----	-----	1.38	-----	-----	-----	-----	13.13	
May 12.....	13.13	0.54	0.63	0.73	.94	1.38	0.97	0.68	-----	-----	7.57	
May 31.....	4.37	-----	-----	-----	.75	-----	-----	-----	-----	-----	3.99	
	6.02	-----	-----	-----	-----	1.43	1.24	-----	-----	-----	4.75	
Means.....		(.54)	(.63)	(.73)	.95	1.33	(1.10)	(.68)	-----	-----		
Departures.....		-.09	-.09	-.11	-.06	+.05	+.16	-.11	-----	-----		

## MADISON, WIS.

May 6.....	4.57				1.26	1.44	1.25				4.75
May 10.....	6.76		0.97	1.11	1.28	1.51					7.87
May 11.....	4.75		1.02	1.16	1.32	1.51					4.37
May 12.....	3.81		.81	1.00	1.30	1.50					4.05
May 13.....	3.63		.98	1.10	1.22						3.99
May 16.....	6.76		.98	1.11	1.28	1.49					6.50
May 24.....	5.79		1.04	1.18	1.32	1.52					5.56
Means.....			.97	1.11	1.28	1.50	(1.25)				
Departures.....			+.13	+.10	+.16	+.12	+.20				

## LINCOLN, NEBR.

May 2.....	13.61					1.39					10.97
May 3.....	15.65					1.39	1.06				10.59
May 5.....	6.50					1.24	1.49				7.29
May 8.....	4.37	0.83	0.96	1.12	1.31	1.54					4.57
May 9.....	5.79	.87	.93	1.11	1.31	1.51	1.29	1.10	0.98	.86	5.79
May 10.....	6.02		.86	.95	1.23	1.49		.92			7.04
May 11.....	9.33			1.06							9.83
May 13.....	6.50	.68	.77	.86	1.14						8.48
May 14.....	5.56					.86					4.37
May 22.....	7.29		.82	.91							8.48
May 23.....	9.47					1.49	1.27				5.36
May 27.....	10.97	.36	.49	.67							9.47
May 28.....	9.14		.54	.65							13.13
Means.....		.68	.77	.92	1.25	1.40	1.21	(1.01)	(.98)	(.86)	
Departures.....		+.03	-.01	.00	+.14	+.02	+.10	+.10	+.17	+.18	

## BLUE HILL, MASS.

May 21.....	9.2					1.48	1.24	1.17			8.8
May 22.....	9.9						1.19	.96	0.79		9.9
May 30.....	5.4			1.06	1.24	1.48	1.26	1.08	.93		5.0
May 31.....	5.6				1.26	1.47	1.07	.89			5.2
Means.....				(1.06)	(1.25)	1.48	1.19	1.02	(.86)		
Departures.....				-.02	+.12	+.11	+.09	+.10	+.05		

\*Extrapolated.

TABLE 2.—Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface

Week beginning—	Gram-calories per square centimeter																
	Washing- ton	Madison	Lincoln	Chicago	New York	Fresno	Fairbanks	Twin Falls	La Jolla	Miami	New Orleans	Riverside	Blue Hill	San Juan	Friday Harbor	Ithaca	Newport
Apr. 30.....	488	542	394	550	446	551	472	438	587	530	392	489	533	494	514	432	605
May 7.....	416	456	468	468	391	678	450	590	593	468	417	618	398	690	490	214	478
May 14.....	288	303	369	281	325	612	463	474	331	529	458	310	446	660	698	331	495
May 21.....	345	497	538	418	403	713	497	866	529	478	497	646	415	704	712	425	458
May 28.....	439	452	536	518	598	714	432	733	523	383	530	606	616	663	644	600	682
Departures of daily totals from normals																	
Apr. 30.....	+21	+101	-77	+166	+40	-74	+70	-75	+16	+63	-3	-63	+30	-57	-50	+72	-----
May 7.....	-37	+73	+19	+68	-1	+27	-1	+2	+23	-53	+20	+62	-93	+154	-49	-198	-----
May 14.....	-175	-173	-147	-141	-86	-57	-4	-134	-177	+36	+52	-207	-49	+112	+143	-66	-----
May 21.....	-155	+5	-16	-34	-45	+37	+43	+19	+58	-23	+76	+111	-138	+153	+138	-107	-----
May 28.....	-91	-45	+15	+49	+131	+27	+13	+141	-11	-103	+29	+53	+50	+95	+89	+83	-----
Accumulated departures since Jan 1																	
	-8,733	-4,081	-2,534	+2,044	+763	-2,954	+3,199	-4,727	-770	-1,281	+3,913	-1,897	-1,344	+6,949	+6,923	+2,135	-----

## POSITIONS AND AREAS OF SUN SPOTS

## POSITIONS AND AREAS OF SUN SPOTS—Continued

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent, U. S. Naval Observatory. Data furnished by the U. S. Naval Observatory in cooperation with Harvard and Mount Wilson Observatories. The difference in longitude is measured from the central meridian, positive west. The north latitude is positive. Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area for each day includes spots and groups.]

Date	East- ern stand- ard time	Mt. Wilson group No.	Heliographic			Area		Spot count	Observatory	1938 May 5.....	time h. m.	No.	longi- tude	tude	tude	group	each day		
			Diff. in longi- tude	Longi- tude	Lat- tude	Spot or group	Total for each day												
1938			°	°	°								°	°	°				
May 1.....	h. m. 11 29	5872	-40.0	263.9	-22.0	194	-----	5	U. S. Naval.	May 6.....	11 17	5868	+25.0	276.2	-22.0	412	-----	22	U. S. Naval.
		5871	-35.0	268.9	+25.0	170	-----	3				5869	+32.0	283.2	+23.0	194	-----	2	
		5870	-31.0	272.9	-30.0	48	-----	3				5867	+32.0	283.2	-30.0	339	-----	14	
		5868	-24.0	279.9	-21.0	48	-----	13				5873	+35.0	286.2	-20.0	61	-----	8	
		5869	-21.0	282.9	+23.0	339	-----	8				5865	+80.0	331.2	-19.0	12	-----	1	
		(*)	-20.0	283.9	+12.0	48	-----	3				5875	+80.0	331.2	+21.0	12	2,254	-----	1
		5867	-19.5	284.4	-29.0	485	-----	5				5878	-67.5	170.4	+23.5	97	-----	1	Do.
		5873	-19.0	284.9	-20.0	97	-----	1				5877	-50.5	187.4	-8.0	533	-----	20	
		5865	+27.5	331.4	-19.5	61	-----	1				5874	-20.0	217.9	-4.5	48	-----	2	
		5862	+40.0	343.9	+9.0	194	-----	3				5876	-4.0	233.9	-37.0	291	-----	30	
		5864	+42.5	346.4	+12.0	315	1,999	9				5872	+26.0	263.9	-23.0	97	-----	3	
		5874	-74.0	216.7	-3.5	194	-----	3	Do.			5871	+31.0	268.9	+25.0	121	-----	5	
		5872	-25.0	265.7	-22.0	170	-----	6				5868	+37.0	274.9	-22.0	242	-----	10	
		5871	-21.0	269.7	+25.0	170	-----	4				5869	+45.0	282.9	+23.0	194	-----	2	
		5868	-13.0	277.7	-22.0	145	-----	15				5867	+46.0	283.9	-30.0	291	-----	5	
		5869	-8.5	282.2	+23.0	291	-----	12				5873	+49.0	286.9	-20.0	48	1,962	-----	2
		5873	-7.0	283.7	-20.0	73	-----	1				5883	-88.0	136.8	-25.0	194	-----	2	Do.
		(*)	-7.0	283.7	+11.0	48	-----	3				5881	-72.0	152.8	+25.0	121	-----	5	
		5867	-6.0	284.7	-29.0	339	-----	6				5878	-53.0	171.8	+24.0	73	-----	2	
		5865	+40.5	331.2	-19.5	61	-----	1				5877	-37.0	187.8	-8.0	776	-----	20	
		5862	+54.0	344.7	+9.0	194	-----	1				5880	-19.0	205.8	+23.0	48	-----	5	
		5864	+56.0	346.7	+12.0	388	2,073	8	Do.			5874	-7.0	217.8	-5.0	36	-----	3	
		5874	-60.0	217.5	-3.5	97	-----	4				5876	+9.0	233.8	-37.0	339	-----	22	
		5872	-12.0	265.5	-23.0	170	-----	4				5872	+39.0	263.8	-23.0	97	-----	4	
		5871	-9.0	268.5	+25.0	291	-----	8				5871	+45.0	269.8	+25.0	97	-----	4	
		5868	-3.0	274.5	-22.0	485	-----	40				5868	+50.0	274.8	-22.5	145	-----	8	
		5869	+7.0	284.5	+23.0	218	-----	6				5869	+58.0	282.8	+24.0	194	-----	2	
		5873	+7.0	284.5	-20.0	73	-----	3				5867	+59.5	284.3	-30.0	242	-----	4	
		5867	+7.0	284.5	-29.0	339	-----	10				5873	+60.5	285.3	-20.0	48	-----	1	
		(*)	+8.0	285.5	+11.0	12	-----	4				5879	+78.0	302.8	-9.0	12	2,422	-----	4
		5865	+53.0	330.5	-20.0	48	-----	3				5883	-75.0	136.7	-24.0	212	-----	4	Mt. Wilson.
		5862	+68.0	345.5	+9.0	194	-----	3				5881	-57.0	154.7	+24.0	194	-----	7	
		5864	+70.0	347.5	+12.0	145	2,072	4	Do.			5878	-39.0	172.7	+24.0	97	-----	1	
		5877	-77.0	187.6	-8.0	388	-----	8				5884	-30.0	181.7	+18.0	73	-----	5	
		5874	-47.5	217.1	-4.0	97	-----	7				5877	-24.0	187.7	-7.0	970	-----	15	
		5876	-29.5	235.1	-38.0	218	-----	24				5880	-7.0	204.7	+24.0	73	-----	6	
		5872	0.0	264.6	-23.0	121	-----	4				5874	+7.0	218.7	-5.0	24	-----	1	
		5871	+3.0	267.6	+25.0	194	-----	10				5876	+22.0	233.7	-37.0	339	-----	26	
		5868	+11.0	275.6	-22.0	436	-----	48				5872	+50.5	262.2	-23.0	61	-----	1	
		5869	+19.0	283.6	+23.0	194	-----	4				5871	+60.0	271.7	+25.0	97	-----	3	
		5867	+19.0	283.6	-29.0	339	-----	8				5868	+63.0	274.7	-23.0	145	-----	3	
		5873	+21.0	285.6	-20.0	61	-----	3				5869	+70.0	281.7	+24.0	242	-----	1	
		5865	+67.0	331.6	-19.5	36	-----	2				5867	+71.0	282.7	-30.0	242	-----	3	
		5875	+67.0	331.6	+20.0	48	-----	8				5873	+74.0	285.7	-30.0	48	2,847	-----	1
		5862	+82.0	346.6	+9.0	194	-----	2				5887	-78.0	120.3	-19.0	97	-----	6	U. S. Naval.
		5864	+85.0	349.6	+12.0	97	2,423	3	Do.			5886	-77.0	121.3	+17.0	97	-----	6	
		5878	-81.0	170.2	+23.5	194	-----	2				5883	-60.0	138.3	-25.0	291	-----	12	
		5877	-64.0	187.2	-8.0	485	-----	30				5885	-43.0	155.3	-13.0	12	-----	3	
		5874	-33.0	218.2	-4.5	61	-----	4				5881	-42.0	156.3	+25.0	291	-----	13	
		5876	-16.0	235.2	-37.0	242	-----	20				5878	-26.0	172.3	+24.0	97	-----	2	
		5872	+13.0	264.2	-23.0	97	-----	3				5884	-16.0	182.3	+18.5	73	-----	23	
		5871	+18.0	269.2	+25.0	145	-----	7				5877	-11.0	187.3	-7.0	1,018	-----	35	

See footnotes at end of table.